Understanding the World Around You

Lessons in Environmental Science for Elementary School Teachers and Their Students

An Honors Thesis (HONRS 499)

by

Karen N. Teliha

Thesis Advisor
Dr. Timothy F. Lyon

Timothy F. Lyon

Ball State University

Muncie, Indiana

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Written By: Karen N. Teliha
Edited by: Dr. Timothy Lyon

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Abstract

The following pages contain information and experiments for teachers and students interested in learning about their environment. Questions such as "Why do I see my breath in the winter?" and "How does a hot air balloon rise?" are answered by performing simple experiments and applying their new found knowledge to practical applications.

This information is divided into three main areas; air, soil, and water. Each section is divided into two parts; the basic properties of air, soil, or water with experiments to apply this knowledge and ecological problems concerning these subjects followed by related experiments. The main focus is to have children learn and enjoy science in a hands-on manner by explaining difficult concepts with simple experiments. The emphasis is on allowing children to research and answer their own questions by teaching them how scientists use hypotheses. These lessons are a change from "spoon feeding" information from teacher to student into cooperative learning of student from teacher and teacher from student. Small group interaction and cooperation is greatly encouraged as well.

The experiments were designed to allow teachers to use cost effective, household items. Pictures have been included to visually explain the experiments. A brief, yet thorough explanation of the science behind each experiment is also provided.

Acknowlegements

I feel I am one of the few students who is able to say that I thoroughly enjoyed researching and writing my thesis from beginning to end. This would not have been possible without the gentle guidance and encouragement I have received from several very important people. Some of these people have helped me for many years and others for just a few short months, but together they have helped me to accomplish a project, which I feel is the capstone of my college education at Ball State University.

I wish to express heartfelt thanks to Dr. Lyon for his time, effort, consideration, and guidance throughout my thesis project. Although I felt I had completed much of the background work for my thesis by the time I asked him to be my advisor, I was certainly surprised at the amount of work still to be finished. I am very grateful for the time he has dedicated to my thesis and for his availability at a moments notice. His steady guidance and encouragement was much needed and appreciated during a very busy period for me.

Mrs. Vandivier is a very important figure in my life who, without knowing it, gave me the idea for my honors thesis. By caring about her former students and their lives, she instilled a responsibility in me to show others how fun science can be. I cannot express to her how much joy I get when I go into her classroom, set up the lessons I have planned, and watch the expressions on the childrens' faces as they actually enjoy learning. Her ability as a teacher is well proven, but she far surpasses others because of her continued dedication to caring about her students.

Finally, I wish to thank my parents who have shown me unfaltering encouragement and support throughout my years at Ball State. They are my strength and all that I have accomplished is due to their dedication and guidance.

Introduction

As I have taught the following lessons over the past years, I have found several approaches that worked better than others. I am sure that these ideas may work better in some classrooms than in others. Trial and error seem to be the best approach in determining what will allow the children to get the most out of each experiment.

Without a doubt, dividing the classroom into groups of three to five students per group allows each child to take part. Encourage them to work closely in their groups by having one child read the directions for the experiment, another perform the experiment, and another record data and write down a hypothesis. Not only does group work give more individual attention, but it allows the children to work together to answer each others questions and solve problems. This is probably the most basic concern in environmental issues. No problem is one sided and there are many views that need to be taken into account. A very important aspect of environmental science is that it takes all kinds of interests to solve the problems involved. Obviously scientists are needed. But there are many types of scientists: environmental, chemical, biological, physical, geological, hydrological, and many more. Engineers, mathematicians, activists, researchers, politicians, and average citizens are all necessary to make positive influences on how we treat this planet. No matter what your interests may be, it is possible for everyone to have a role in how we will all be able to live together in harmony with nature.

When working in small groups, I did notice and become frustrated with the arguing between the children when they did not agree on the way something should be done. Please do not let this discourage you from group work. Working together and understanding differences is a huge challenge for adults, so problems are to be expected when working with children. The sooner they learn the art of compromise and consideration, the more successful they will be in the future.

Because the groups will be small, you will need more than one experiment going at a time. Five to six stations can be set-up around the classroom. You can allow each group to spend ten to fifteen minutes at each station and move on to the next. Written instructions and questions can be located at each station. Most experiments are simple and safe for the children to perform. Others may require adult supervision. It may be necessary to have more than one adult present.

You will notice that each experiment suggests that the students form a hypothesis. A hypothesis is what the children think will happen. It is an educated guess. Let them do this after you have explained the scientific principles behind the experiment and they have seen the set-up of the experiment. I suggest they write down their hypothesis. When the experiment is complete, they can compare how close they were. It is important for them to understand that scientists always hypothesize. Sometimes they are right but often they are wrong. This is the whole process of scientific discovery. I suggest that the students keep lab notebooks to write down new words they encounter or questions they may have about an experiment. This is a good place to write down the hypothesis.

Perform each experiment before you present it to the class. This way you know what the results should be. It will also allow you to make any needed revisions. A major goal of the experiments is to use easy-to-find, cheap, household products. There may be many ways to revise an experiment to fit the items you have to work with.

In my own school experience, I have found that I learn the most by doing my own research. The text presented here is very short and only skims the surface of most issues. Have the students write reports on some of the issues brought up in the text. This will allow them to apply environmental science in a way that interests them. It will also show them how inter-related environmental issues are. Air, water, and soil are a part of a cycle that cannot be separated. Changes in one affect the other. You cannot really understand one without understanding the others.

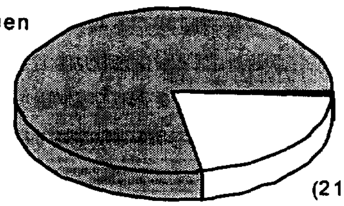
Role-playing is an excellent way for children to understand the different issues involved in any problem. Dividing the class into farmers, families, and environmentalist will let each group explore reasons behind why something is done. Farmers do not use insecticides to purposely harm birds. They need to produce bountiful harvests so they can buy food and clothing for their own families. Families in the community want fresh-looking and good-tasting produce, but they are also concerned about the health of their children. Have guest speakers representing different views found in the community talk to the class. They can bring in perspectives different from any you will read in a book. Field trips to the water treatment plant, wastewater treatment plant, landfill, nature park, zoo, or farm can also be helpful. Even a trip to the state environmental agency can be a very beneficial way to show to children the many interests needed for environmental issues.

One warning to take into consideration. Do not allow the children to become overwhelmed by environmental problems. Many facts you may read in some texts are very sad and upsetting. It is important that everyone understand the seriousness of environmental problems, but do not allow a doomsday outlook to overshadow their views. The purpose of teaching environmental science is to give everyone a feeling of responsibility toward their surroundings and to have an understanding and appreciation for the cycles found in nature. Everyone needs to know how they impact other species of life. By better understanding our surroundings, we will know how to live in harmony with them.

Our Air and Atmosphere

What is the air we breathe made of?

When humans, as well as other mammals breathe, we are actually utilizing the oxygen in the air and exhaling carbon dioxide. These are not the only two gases that combine to form the air that is present around us. The air at the surface of the earth is actually a mixture of many molecules all in the form of gases. The majority of the air, 78% is nitrogen gas. Oxygen only makes up about 21% of the air we breathe. That leaves only 1% for all the other gases present in our atmosphere, including carbon dioxide, water vapor, and ozone.



What do molecules of air look like?

Nitrogen, oxygen, carbon dioxide, water vapor, and ozone are all **molecules** that are made of individual **atoms**. For example, **nitrogen** not found as just one nitrogen atom floating around. It is actually two nitrogen atoms chemically attracted to each other to form one molecule of nitrogen. Scientists have used a shortcut to describe atoms. A nitrogen atom is abbreviated as N. So, two nitrogen atoms to form a molecule would be represented by N_2. An **oxygen** molecule is very similar to nitrogen, it is two oxygen atoms combined to form one oxygen molecule.

O - O **N - N**

O_2 N_2

If a third oxygen is added to the O_2 gas molecule, it is no longer ordinary oxygen that we breathe. It has become O_3, **ozone**. This is an extremely important gas used to form the ozone layer which will be discussed later.

O - O - O

O_3

Carbon dioxide is the gas exhaled by humans and is also found naturally in the atmosphere. An overabundance of carbon dioxide has been a large contributor to heating the atmosphere, also known as the greenhouse effect. Carbon dioxide is made up of one carbon atom and two oxygen atoms. The abbreviation looks like this: CO_2.

O - C - O

CO_2

Layers of the Atmosphere

The atmosphere has several different layers. Each layer has many of its own characteristics, and each has a specific purpose important to the survival of life on Earth. The most significant purposes of the atmosphere are to hold in warmth from the sun and to block the sun's harmful rays. The atmosphere extends more than 50 miles above the surface of the Earth. The layer we have the most contact with is called the **troposphere**. This is the layer closest to the Earth, and is the one most effected by gravity. Gravity pulls on the gas molecules and holds most of the air molecules close to the surface of the Earth. Therefore, the troposphere contains more gases than any other layer. Because the Earth has drastic temperature changes, it effects the air immediately above the planet. The constant variation in temperature makes the troposphere very unstable. This is why the troposphere is the layer where weather and wind occur.

The **stratosphere** is the layer above the troposphere. This layer is important to all life on Earth because it contains the **ozone layer**. The ozone layer provides protection against the sun's harmful ultraviolet radiation by using ozone (O_3) to stop the rays. Although there are many types of ultraviolet rays, UV-B rays are the most harmful and are blocked by ozone. When the UV-B rays hit an O_3 molecule, the O_3 splits into O_2 and O but absorbs the UV-B rays. Airplanes fly in the stratosphere because there are very few clouds to block the view.

The next layer, the **mesosphere,** is also called the exosphere. This is easily remembered because this is the layer where hydrogen and helium escape (or exit) the atmosphere and are lost to space. The mesosphere contains a layer called the ionosphere. This layer is used by humans to reflect AM radio waves back to Earth. The ionosphere is also the layer in which the northern lights, the aurora borealis, occur.

The final layer of the atmosphere is the **thermosphere**. There really is not an upper limit to the thermosphere because the molecules continue to become more sparse. but scientists have estimated it to extend to 600 miles above our planet's surface. Temperatures are extremely hot, around 2000°F but do not really exceed this since there are not enough molecules to heat up.

How do we use air?

All living things need air to survive. Air is not a liquid like water or a solid like a table. Air is a gas. Each living organism utilizes different gases from the air. People and animals inhale oxygen and exhale carbon dioxide. Plants take in carbon dioxide and release oxygen. This provides a continuous cycle for life.

Topic: Air: **Air is Lighter than Water**

Objectives:
1. To prove that air is lighter than water.
2. To control the depth of plastic bottle by the amount of air in it.

Materials:
3 Pennies
1 Plastic two liter bottle
1 Small balloon
1 Straw
Tape
Sink or basin large enough to lay the bottle in

Background Information:

Submarines are underwater boats that are able to control their depth underneath the water by using air. The submarine you will make will be able to sink and rise by either increasing the amount of air or water inside the bottle. Since air is lighter than water, the submarine will rise if you blow air in and will sink if you suck air out.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:
1. Poke three holes about an inch apart in a line along the bottom of the bottle.
2. Between each hole, tape a penny to the bottle. These will be weights to hold the holes underwater.
3. Stretch a balloon over the mouth of the bottle. It does not need to be stretched tight.
4. Cut a tiny hole in the top of the balloon and place about an inch of the straw into the hole.

5. Fill a sink with water. Place the bottle in the water and hold it down so water enters through the holes and fills it until it sinks.
6. Now have a child blow through the straw and watch what happens to the submarine. Have them try to suck the air out.

Evaluation:
1. Have the children explain what happened as air was blown in or sucked out.
2. Ask the children which they think is heavier, air or water.

Application: Have the children explain with what they have learned in this experiment, such as why rafts float at a lake or pool.

Sources: WalPole, Brenda. **Fun with Science: Air**. Warwick Press, New York: 1987.

Topic: Air: **Temperature and Air**

Objectives:
1. To observe and understand the effects of hot and cold temperatures on air.
2. To apply this knowledge to everyday occurances.

Materials:
1 Two liter plastic bottle (soft drink bottle)
1 Small balloon
A sink with both hot and cold water
(If no sink is available, a five gallon bucket containing ice water and a large crock pot with warm/hot water in it will also work.)

Background Information:

Begin by having the children stand up at their desks and asking them what they would do if it was winter and you turned off the heat and opened the windows. They would not be allowed to put additional clothing on. (They may answer by shivering, but try to steer them in the direction of gathering closer together to use body heat to keep each other warm). Now ask what would happen if you suddenly turned the heat all the way up and it was extremely hot in the classroom. (The children should spread out around the room to avoid the body heat of the group). Let them observe that when they were cold, they only needed a small portion of the room. When they were hot, each person wanted much more space and as a class, they took up much more room even though there was exactly the same number of children in the room as before.

Tell the children that each of them is an air molecule such as oxygen, nitrogen, or carbon dioxide. Air molecules will do the same thing that the children did when air gets hot or cold. They will take up much less space if it is cold because the molecules gather as close as possible, but will need more space when it is warmer.

Now try the experiment.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:
1. Stretch the opening of the balloon around the spout of the bottle. Make sure the children understand that no air is able to get out or go into the bottle. The air that is in there now is the same amount of air that there will always be throughout the experiment.
2. Fill the sink halfway with cold water. You may want to add ice if it is not cold enough.
3. Place the bottom of the bottle in the water. Do not let the balloon rest in the water.
4. Let it remain in the cold water until the children notice what has happened

to the balloon. (It should have been sucked into the bottle.)

5. Remove the bottle from the sink and drain the water out of the sink.
6. Now fill the sink halfway with warm/hot water. Be careful the water will not burn the children.
7. Place the bottom of the bottle in the water. Do not let the balloon rest in the water.
8. Let it remain in the hot water until the children are able to see a change in the balloon. (It should have popped back out of the bottle and if left in the warm water long enough, it will begin to expand a little.)

Evaluation:

1. Have the children describe the changes the balloon had undergone.
2. Why did these changes happen based on the activity performed before the experiment?

Application: Based on the knowledge the children have gained from this experiment, have them describe what might happen to their bicycle tires in the winter or in the summer if they do not add any air or take any away.

What do they think might happen to a balloon filled with air that is placed over the heater?

Sources: WalPole, Brenda. **Fun with Science: Air**. Warwick Press, New York: 1987.

Topic: Air: **Does Air take up Space?**

Objectives:
1. To understand that air is a gas and that gases take up space.
2. To understand that air is lighter than water.

Materials:
2 Mayonnaise jars
1 Large balloon
1 Small funnel
2 Flexible drinking straws
1 Large container with about 2 inch sides
1 Piece of cardboard, 4" x 4"
1 Plastic cup
1 Ruler

Background Information:

Many children do not realize that a gas such as air, takes up space. Ask the children if any of them is able to capture some air for you. After taking their suggestions, call one child forward and give him a balloon to blow into. Hold up the full balloon so that everyone can see that it is possible to capture air. Ask them why the balloon does not look like it did before. Let them know that air has pressure and it is pushing on the outside of the balloon and makes the balloon puff out.

We cannot see, smell, taste, or touch air, but it has properties just like a liquid or a solid would have. Hold up an "empty" jar and a jar containing water. First ask them what is in the jar with water, then ask what is in the other jar. Be sure they understand that the jar is not empty but rather it is full of air. Air can fill up a jar just as water does. Have them speculate on what would need to happen to the air in the jar if you would pour the water from the other jar into the "empty" one. The air must exit the jar in order to make room for the water.

Now explain that they will be performing an experiment to prove that air must leave in order to make room for water.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:
1. It would be best to have the equipment set up before you show it to the class.
   A. Place one mayonnaise jar upside-down inside the container.
   B. Stretch a balloon over the mouth of the other mayonnaise jar. It works best if the balloon is stretched flat. It may be necessary to use a rubberband to keep the balloon on the jar.

C. Make two very tiny incisions in the balloon. They should be at opposite sides of the mouth of the jar but at least a half inch from the sides of the jar.

D. Place a straw about a half inch into one of the holes. The balloon should seal around the straw so no air can escape.

E. Place the small end of the funnel into the other hole being sure the balloon seals around the funnel. (If the holes are too big, you will need to start again with a new balloon.)

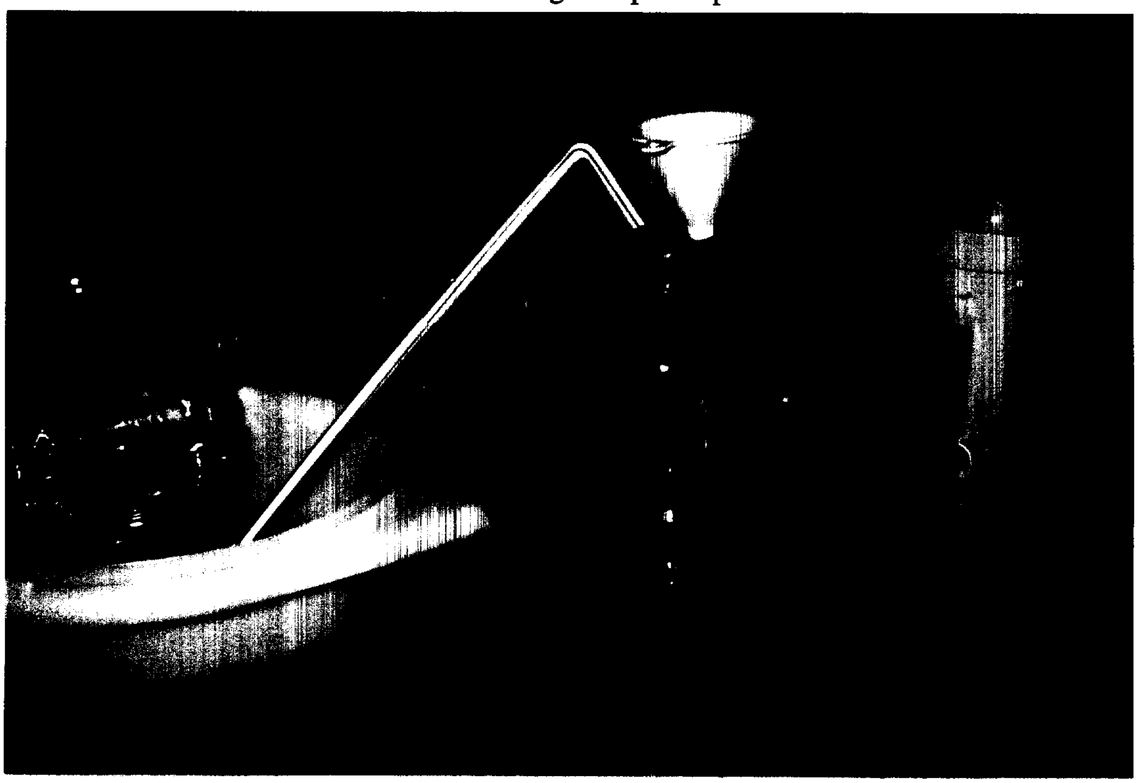
F. Insert the other straw into the end of the straw coming out of the jar. The overlap needs to be about a quarter of an inch.

G. Flex the straws down so that you can place the end of your connected straws underneath the upside-down jar in the container.

H. Place enough water in the container to just cover the opening of the upside-down jar.

I. Remove the upside-down jar and fill it with water to the brim, as full as possible.

J. Now for the tricky part. Using the cardboard, place it over the mouth of the jar. Get as close to the container as possible and hold the cardboard tightly in place over the jar. Quickly flip the jar over, still holding the cardboard on the mouth. Lower the jar into the water in the container. Once the mouth of the jar is covered by the water you previously poured in the container, you can remove the cardboard. Place the straw under the mouth of the jar. Now the children can begin to participate.



2. Point out that one jar is full of water and one jar is full of air.
3. Have one child hold the funnel steadily in place while another child pours water from a cup into the funnel.
4. Have the children watch both jars. As water is being poured into the jar containing air, what is happening to the other jar? Bubbles of air should be coming out through the straw. Be sure the bubbles are being collected in the upside-down jar. (If there are no bubbles, another child may need to tilt the upside-down jar so that the straw is not closed off. Be sure the mouth of the jar remains underwater though.)
5. At some point, stop pouring water in and have one child measure with a ruler how much water has been poured into the jar that had previously contained air only. Now have someone else measure the amount of air that has bubbled to the top of the jar that had previously contained only water. These amounts should be very close to equal.

Evaluation:

1. Let the children explain the path of the air and water in the experiment they just performed.
2. What happened to the air in the "Air Only" jar when water was added?
3. Where did the water from the "Water Only" jar go?
4. Explain that this happened because when water was poured in, it took up the air's space. Since air is lighter than water (see Air is Lighter than Water), the air rose and the water sank. Air was able to take up water's space in the upside-down jar because the air rose to the top and the water sank and escaped out the bottom of the jar into the container.
5. The two measurements should have been identical unless water or air was

escaping by accident. This proves air was in the "Air Only" jar and it was taking up space. The jar was not empty, but full of air.

Application: Try this experiment again, but this time only have one hole in the balloon. Use this hole for the funnel. When water is poured into the funnel (quick enough to cover the funnel hole) the water should just stand in the funnel and not enter the jar. Let the children hypothesize why this occurs. (The air is taking up all the space and this time it has no way to escape to make room for the water.)

Now pour only a trickle of water into the funnel. The water is entering the jar. How? You have left enough room in the funnel for air to come out the same hole as the water going in.

Have the children think about how this is useful in the kitchen. Think of a chocolate syrup container or a juice drink container. In order to pour the liquid out, you must make another hole in the top for air to go in. Think of when you drink out of a small mouth container. Your mouth cannot cover the whole opening or else nothing will come out.

Topic: Air: **How much does Air Weigh?**

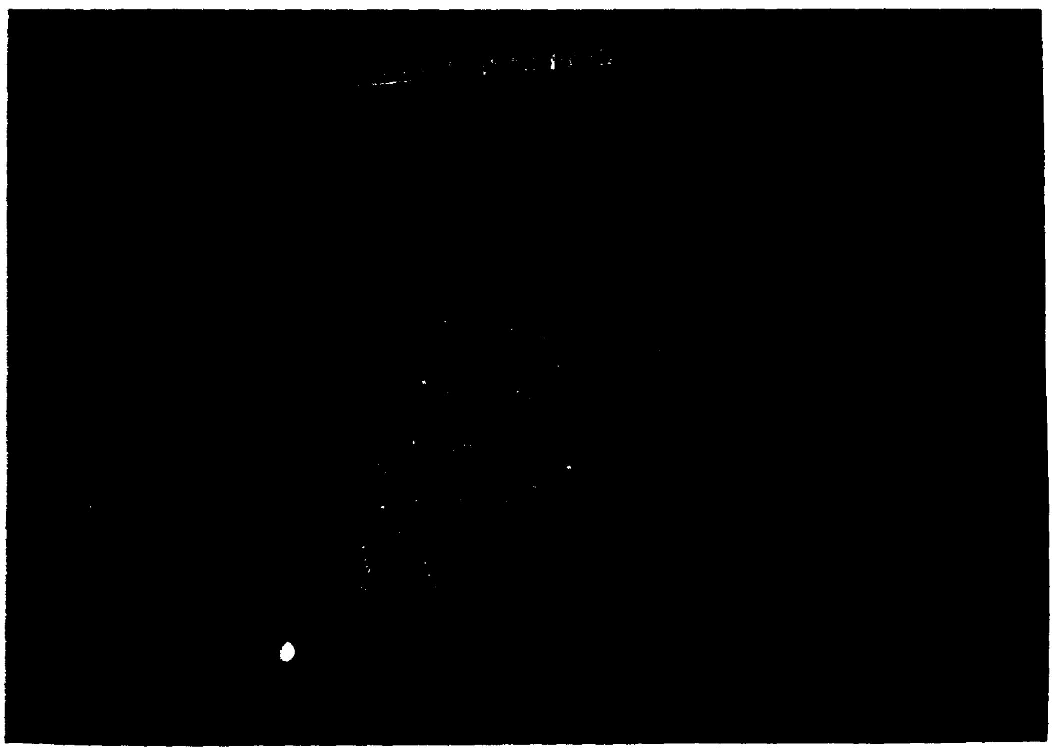
Objectives: 1. To prove that air is not weightless.

Materials:
Yard or meter stick
Thread
Scissors
Tape
2 Balloons exactly the same size

Background Information:

Air is very light. When we lift a bottle or a bucket we do not think that the air inside is making it heavier and more difficult to lift. Have a child lift an "empty" bucket in front of the class. Ask the child if it was heavy. When they say no, ask why not, it was full of air wasn't it? Air is very light compared to the weight of the bucket. Air does have a mass though. Each atom that makes up a molecule of air weighs something. The best way to actually see that air weighs something is to compare it to itself.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.



Procedure:

1. Cut of a piece of thread 12 inches long. Tie it around the yard stick and tape it to the exact center of the stick. Adjust the location of the thread until it balances. When you hold the yard stick by this thread, it should balance perfectly.
2. Cut two pieces of thread each 36 inches long. Tie one to each end of the yard stick and tape them securely in place 5 inches from each end.
3. Tie a deflated balloon to each end of the thread. The yard stick should balance perfectly.
4. Remove one of the deflated balloons, blow it up, and tie it back to the thread. Now which end is heavier?

Evaluation:

1. Which was heavier, the deflated balloon or the balloon full of air. Explain.

Application: Based on the experiment Temperature and Air, ask the children what they think would happen if you filled a balloon up with hot air. Remember that hot air molecules spread out and take up more space. If you heat up air and then inflate a balloon with this hot air, it should actually take less air than if you inflated a balloon with room temperature air. Since there is less air, fewer molecules, the hot air balloon should actually weigh less than the room temperature air balloon. Using this concept, how do the children think a hot air balloon rises?

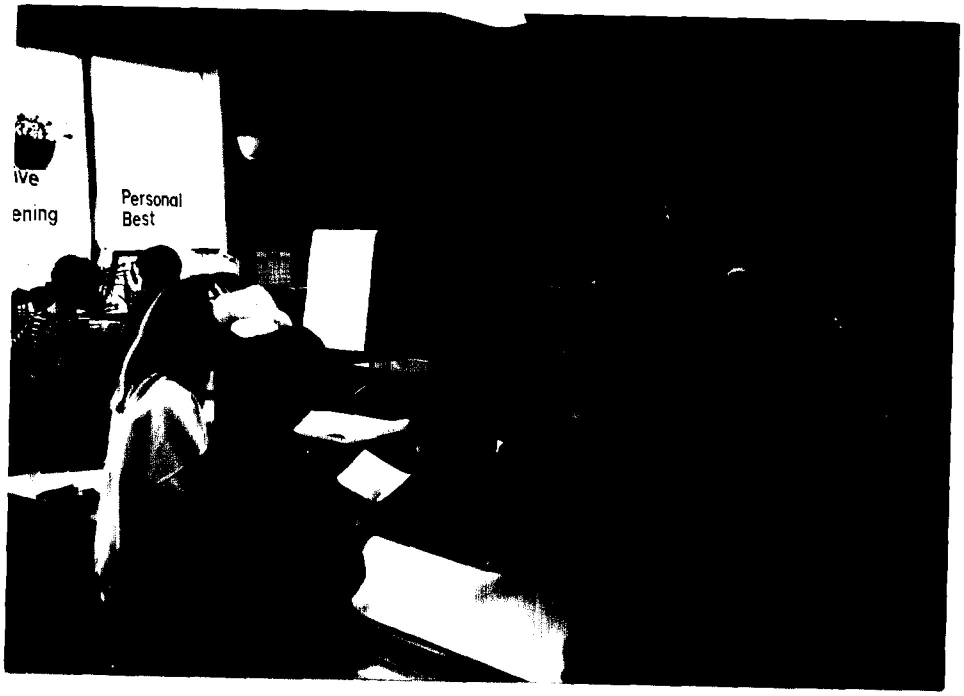
Sources: Broekel, Ray. **Experiments with Air**. Children's Press, Chicago: 1988.

Air Pollution Issues

Pollution

How do we pollute the air?

People make the air dirty by adding **pollutants**. Pollutants can be gases or tiny particles carried in the air. Sometimes you can smell or even see pollutants. Pollutants come from burning things for fuel such as gasoline for cars, coal in factories, and wood for heating. Pollutants make it difficult for people and animals as well as plants to breathe. Polluted air can also cause damage to buildings and statues.



Nature also produces its own pollutants. A major source of natural pollutants is ash from volcanoes. Sometimes so much ash is released that the sky is dark for days.

One problem facing countries today are pollutants that do not stay in the area where they are released. Pollutants travel with the wind and can be carried hundreds of miles. Many countries become upset when they try hard to limit pollution from factories inside their border but still suffer the effects of acid rain or polluted air from neighboring countries which allow pollution.

Greenhouse Effect

What is the greenhouse effect?

The **greenhouse effect** has only recently been observed. If you have ever been in a car with the windows rolled up and the sun shining in, you have experienced the greenhouse effect. Light comes in through the windows and changes to heat which cannot escape. This is what scientists feel may happen to the Earth: a general global warming.

Sources of greenhouse gases

A gas commonly found in the atmosphere, **carbon dioxide**, is a major source of heat retention. Carbon dioxide, which is the gas exhaled by animals and released when any organic material is burned, is able to hold heat that normally would escape to space. On Earth, carbon dioxide is what has allowed temperatures to remain at livable condition. But now, factories, industries, and automobiles have caused an increase in the emissions of carbon dioxide. Organic materials such as wood, gasoline, natural gas, or petroleum are burned because they provide fuel for heat, transportation, and many processes in factories. When organic materials are burned, another greenhouse gas called **nitrous oxide**, N_2O is released. Nitrous oxide is also released when farmers fertilize their fields. Bacteria in the soil breaks down the fertilizer and release **methane**, CH_3, a greenhouse gas. Methane is actually released in large quantities by cattle and landfills. Both methane and nitrous oxide hold heat just as carbon dioxide does.

Chlorofluorocarbons (CFCs) are greenhouse gasses that also damage the ozone layer. These gases have been produced by humans alone. Fortunately, the use of CFCs in air conditioning units, refrigerators, spray cans, and certain plastics are being quickly replaced with other materials.

Ozone Layer

CFCs have not only caused problems with global warming, but their effects have also been found to be harmful to the ozone layer. The ozone layer is made of ozone molecules that break down and absorb the UV-B rays from the sun. Ozone will continue in a cycle combining to make more O_3 molecules. But, when a CFC reacts with ozone, it destroys the O_3 and makes O_2 and O and quickly moves on to the next O_3 molecule. It all happens so rapidly that the formation of ozone molecules is unable to keep up with the destruction. This causes the ozone layer to become very thin. Some areas, such as the area over Antarctica and Australia, are much thinner then others. This is where the actual "holes" in the ozone layer are occurring. With less protection from the harmful UV-B rays from the sun, people who live in these areas are much more likely to develop skin cancer and eye problems. Increased UV-B rays at the earth's surface also cause many problems with the plants and animals. If plants are dying due to UV-B rays, what will happen to the animals that depend on these plants to live?

Acid Rain

Acid rain, more accurately called acid precipitation because is can be carried in snow, sleet, or rain, has been studied for many decades. Acid precipitation affects mainly plants, waterways such as streams or lakes, and soil communities are beginning to show evidence of low pH readings. pH is a measure of acidity. A pH of 7 is considered neutral while readings below 7 are acidic. Rain is naturally acidic and normally has a pH of about 5.6. If the pH falls below 5.6, it is abnormally low and is considered acid precipitation. Precipitation picks up additional acidity due to human sources of acid gases in the air.

The main gases causing the most concern for acid rain are sulfur oxide and nitrous oxide. These two gases are released through oil or coal combustion from electric power plants, automobiles, and many industries. Coal smoke is released to the atmosphere through smokestacks and can be carried away by the wind. Often, the consequences of acid precipitation are not experienced by the area generating the acid gases because the wind carries the gases away from the source of emissions. Another area will receive the acid precipitation when it rains or snows and then that area's lakes and streams will become acidic.

The pH level in a lake or stream determines the type of life that is able to survive in that ecosystem. If a pH falls to a lower level than the fish are accustomed too, then certain species of fish will die. For instance, some species of bass and trout cannot survive in pH levels lower than 5.0. Mollusks and crayfish are not able to maintain their exoskeleton and shells at low pHs. Even if an animal does not die from acidic water, many times its offspring are born with deformities. Many plants, especially trees, are susceptible to low pH levels. Forest and crop production can suffer.

What do we do now?

Fortunately, levels of emissions of both sulfur and nitrogen gases decreased since the 1970s. Nevertheless, places such as eastern Canada and the northeastern part of the United States have seen many trees, lakes, and streams affected by acid precipitation. The Ohio River Valley is a major contributor to sulfur dioxide pollution thanks to the high sulfur coal burned in electric generating plants. These fuels are a major source of sulfuric and nitric acid. Is it really fair for us to enjoy cheap electricity from polluting power plants when Canada and parts of the U.S. pay for the pollution problems?

Topic: Air: **Effects of Acid Rain**

Objective: 1. To observe the effects of acidity on plant growth.

Materials:
1 Washed milk carton per child (the small, individual serving size cartons)
1-2 seeds per child (radish, clover, pea)
Potting soil
Vinegar
Distilled water

Background Information:

Plants are accustomed to growing with water at a pH of about 5.6. You will be making acidic water at a pH of about 3.0. What will happen to the plants watered with the acidic water?

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:

1. Plant one or two seeds in each milk carton.
2. Make an acidic solution of 1 cup of vinegar with 4 cups of distilled water.
3. Label half the cartons as "Acidic" and the other half "Normal".
4. Water the "Acidic" cartons with your acid solution and the "Normal" cartons with plain distilled water. Be sure you are watering each seedling with an equivalent amounts of water.
5. Watch what happens to the seedlings over a period of days and weeks. Is there a noticeable difference in the acidic seedlings and the normal seedlings. It may be worthwhile for each child to keep a daily log of how much their seedling has grown and how quickly and then the class can compare as a group whose grew quickest and whose looks the most healthy.

Evaluation:

1. Which plants sprouted first? Which grew the most/least?
2. Were there any noticeable traits among those with acidic solution?
3. Does the soil look any different between the "Acidic" and the "Normal" plants?

Application: If acid rain had about the same pH as the acidic solution you used, how might that effect plant growth in nature? Ask the children why it was so important that each plant received an equal amount of water and sunlight. (You were eliminating every type of variation that would affect plant growth. If you watered the plants differently, then that would be the factor effecting how much the plant grew.) This made your experiment as accurate as possible.

Sources: **We Can Make a Difference: Environmental Curriculum**. Three Rivers Solid Waste Management District: 1995.

Topic: Air: **Ozone and Smog**

Objective: 1. To observe the how smog forms and causes ozone pollution.

Materials:
Glass jar
Water
Aluminum foil
2 ice cubes
Paper
Ruler
Scissors
Matches

Background Information:

As discussed in "Selected Air Pollution Issues", the hole in the ozone layer is due to a lack of ozone molecules in the atmosphere. There is another ozone problem close to Earth-too much ozone! The ozone close to Earth is part of smog which is caused by human activities such as automobiles, power plants, and factories. Gases formed by gasoline and diesel fuel are released into the lower atmosphere. When they are heated and struck by sunlight they form smog which contains ozone. High levels of ozone are bad for our health, especially that of sick, elderly, or young. Ozone makes it very difficult to breathe. Listen to the news in your area. More than likely, the weatherman is issuing warnings in the summertime for high ozone levels. To reduce these levels, the weather service advises that no one fill their tanks with gas or mow the lawn during peak times (rush hour traffic).

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure: DO NOT BREATHE THE SMOG

1. Cut a strip of paper about 15 centimeters long. Fold in half lengthwise and twist.
2. Make a lid for the glass jar with a piece of aluminum foil. Remove the lid for now.
3. Put water in the jar and swirl it around until all the inside walls of the jar are wet. Pour the water out.
4. Place the ice cubes on top of the foil lid to make it cold.
5. Light the strip of paper and drop it and the match into the damp jar. Put the foil lid on the jar and seal tightly. Keep the ice cubes on the foil in the middle. Do all of this very quickly.
6. When you are finished viewing the experiment, release the smog outside.

Evaluation: 1. What is happening inside the jar?

Topic: Air: **Greenhouse Effect**

Objective: 1. To observe the how the greenhouse effects temperature.

Materials:
2 Glass jars
3 Thermometers
Paper
Pencil

Background Information:

As discussed in "Air Pollution Issues", greenhouse gases such as carbon dioxide, CFCs, nitrous oxide, and methane are able to hold a tremendous amount of heat in. An excess amount of these gases has had an effect of putting a blanket around the Earth and not allowing excess amounts of heat to be released. This experiment shows how the correct amount of gases allows for release of heat while too much greenhouse gas increases the temperature of the atmosphere.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:
1. Place a thermometer in each jar. Leave one thermometer outside of the jars.
2. Seal one of the jars tightly. Leave the other jar open.
3. Put the equipment outdoors in direct sunlight. Keep the equipment together so that temperatures do not vary due to location of the jars.
4. Record the temperature on each thermometer once each minute until it stops rising.
5. Compare the data you found.

Evaluation:
1. Which jar had the greatest temperature?
2. How long did it take for each thermometer to reach the maximum temperature?
3. Which jar represented Earth with the correct amount of greenhouse gases?
4. Which jar represented Earth with too much greenhouse gas?

Application: Greenhouse gases are on a rise because of human activity. Have the children study what types of activities are causing an increase in carbon dioxide, CFCs, nitrous oxide, and methane. Let them explore ideas for what could be done to reduce these emissions. How will a reduction in these same gases effect ozone levels near the Earth?

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Duden, Jane. **The Ozone Layer**. Crestwood House: New York, 1990.

Hoff, Mary and Mary M. Rodgers. **Our Endangered Planet: Atmosphere**. Lerner Publication: Minneapolis, 1995.

Simon, Seymour. **Projects with Air: A Science at Work Book**. Franklin Watts, Inc.: New York, 1975.

The Nitty Gritty of Soil

Why is soil important to us?

Soil provides many necessities that are often taken for granted by mankind. The food we eat would not be available if there was no fertile soil for planting crops used to grow fruits, vegetables, corn, wheat, and many other plants. Even our sources of meat depend on soil. Cattle are herbivores which munch on grass growing in the soil. These same cattle provide us with meat and milk. The clothing we wear is often made of cotton. Sometimes we wear wool, provided by sheep, another herbivore. The houses we live in can be made from wood cut from trees growing in soil. Some houses are made of bricks which are formed with soil and clay.

For these reasons, soil is an essential resource for our existence. It is necessary for us to understand soil science so that we are able to conserve and protect our soil for future generations.

Starting at the beginning: How is soil made?

The soil we see today was made millions of years ago. Soil formation is a very slow process that is never ending. Rocks are constantly being broken and cracked. The process is so slow that most of us never notice that it is going on. Soil can form in many ways.

Glaciers

Glaciers make a tremendous impact on soil. These large ice blocks are capable of moving tons of rocks and boulders, scraping and crushing them along the way. Not only do glaciers make new soil by smashing rocks into smaller pieces, but glaciers also move soil to new locations. This is why the soils are very thin in Canada and northern Michigan. Much of the topsoil from this area was moved by glaciers into areas of Indiana, Ohio, and Illinois. These Midwestern states have plenty of topsoil which make it ideal for farming. Exposed rocks are being broken down very slowly in Michigan and Canada and thousands of years from now, there will be a new layer of topsoil.

Weathering

The process of rocks cracking and breaking is called **weathering**. Weathering can occur from wind and water hitting exposed rocks and slowly wearing off very tiny pieces of rock. Rivers and streams wear away at rock surfaces. Differences in temperature also cause weathering. When it is hot outside, the rocks will expand. When temperatures fall, the rocks shrink. Both of these effects cause the rock to crumble and crack. Cracking allows water to infiltrate a rock. If there is water available, then certain plants are able to grow on the rock. Plant roots are actually very strong and capable of helping to break rocks and cause additional cracking. If water gets trapped in the cracks of a rock, the water may freeze. When water freezes, it expands and pushes against the rock. This causes even more fractures. Gravity also plays a role in breaking down rocks. Falling rocks will smash and break into a million pieces. All of these examples of weathering are called **mechanical weathering**. Mechanical weathering only changes the size and shape of a rock. It does this by pushing and breaking rocks.

Chemical weathering occurs when rocks are broken down and the actual composition is changed. Carbon dioxide is a gas found naturally in the air. It can form an acid called carbonic acid. This acid also helps to dissolve rocks. Lichens, composed of algae and fungi, grow on the surface of rocks. Lichens produce an acid which helps to dissolve the rock.

Soil is more than just Rock Particles

Small, broken pieces of rocks are not enough to form soil. Soil must contain **minerals** and organic matter. It gets these minerals through tiny microorganisms. When plants or animals die, their bodies eventually decay and become incorporated into the soil. Microorganisms such as bacteria are the creatures that decompose dead materials. Bacteria are essential to life on Earth. Just imagine what it would be like if there were no bacteria to help decompose dead plants and animals. We would be covered in leaves that fall off trees every year. As the bacteria break down dead matter, they return minerals to the soil. Plants, animals, and humans all need minerals to survive. The problem is that humans cannot ingest minerals in the form that they appear in the soil. Plants are able to take up the minerals and store them in their leaves. When we eat plants such as carrots, potatoes, and lettuce, we are able to digest these minerals. There is another type bacteria called **nitrogen fixers**. These bacteria form nodules on the roots of plants called **legumes**. Beans and peas are legumes. These nodules are able to fix nitrogen so that plants can use it. Animals such as moles, ants, and earthworms also help add nutrients to soil and make it more fertile.

Soil Textures

The rock particles that make up soil come in various sizes, ranging from clay, the smallest, through silt and sand, the largest. This is the **texture** of the soil. Soils made up of these particles show different characteristics. Each soil has qualities that make it ideal for some situations and not for others. For example, clay soils do not allow water to infiltrate easily. This would not be a useful condition for a corn field. The plants would not be able to get water. But, clay may be very helpful as a liner in a landfill to prevent contaminated water from escaping the landfill and entering groundwater. Clay particles also attract nutrients in the soil and make them available to plants.

Clay

Clay soils are very compact. They are packed so tightly that there is little room for air and water. This is why plants cannot survive well in a clay soil. Clay feels smooth and sticky when wet. You can form the soil into balls and it doesn't crumble. This is because clay particles are extremely small. They are invisible to the naked eye. In fact, it would take 500,000,000,000 particles of clay to make just one grain of sand.

Sand

Sand particles are very large. Sandy soils feel very gritty when rubbed between two fingers. Sand is also blown very easily by the wind. Water travels very quickly through sandy soils. Most aquifers occur in sandy soils where the water can flow easily.

Silt

Silty soils feel soft. The size of a silt particle is larger than clay but smaller than sand. Silty soil will break into chunks. It holds water fairly well and is capable of supporting different types of plant life.

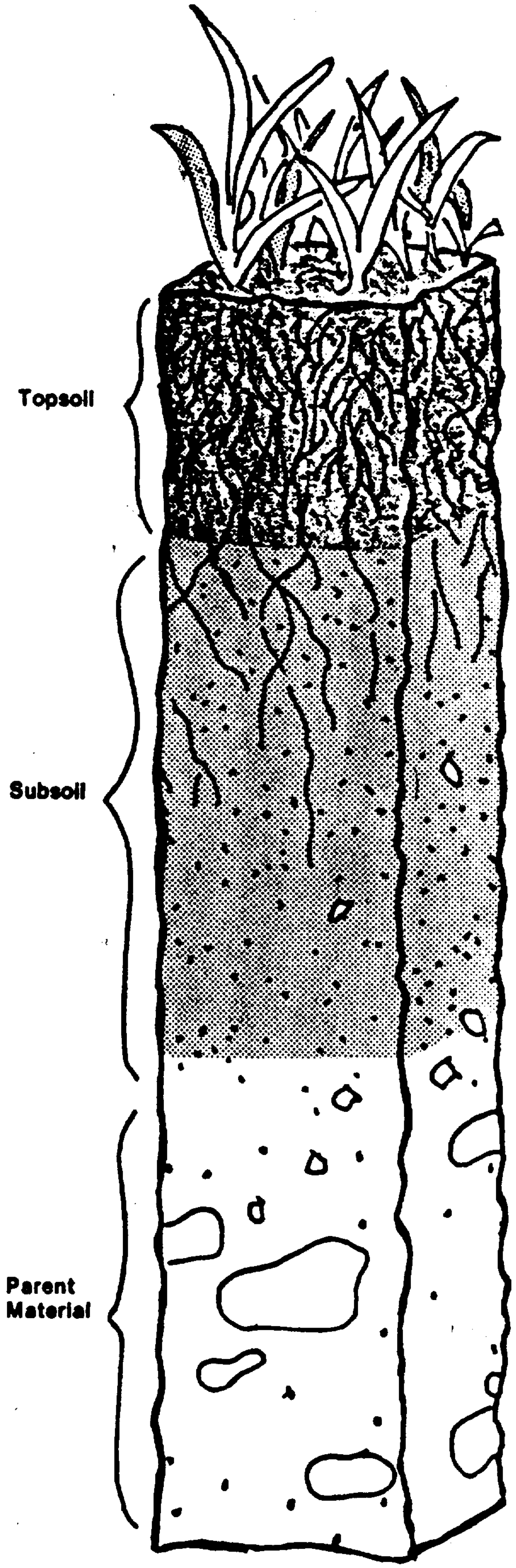
Loam

Loam is a mixture of clay, sand, and silt. Loam soil is beneficial for plants because some clay is good and some sand is good. A mixture of the various textures of soil provides water and nutrients in appropriate amounts. Water can be held by silt and drained by sand.

Soil Profiles

If you were to dig a deep hole in the ground, you would see that there are many layers of soil. These layers are called **horizons** and together they make a **soil profile**.

The first horizon is called humus. **Humus** is not really soil. It is a very dark colored layer made mostly of partly decayed organic matter. Organic matter is anything that is now dead but was once living such as insects, animals, leaves, or twigs. The humus layer is very porous (it has many air pockets) and acts similar to a sponge.



The next horizon is topsoil. **Topsoil** also is dark in color because it contains organic matter, but it contains much more fine, loose soil particles. This allows plant roots to grow easily. The topsoil layer readily absorbs moisture. This layer is approximately 10 to 15 inches deep.

Subsoil is found in the next horizon. The depth of subsoil can vary from a few inches to several feet. Subsoil is a lighter color than topsoil because it has less organic matter. Clay and sand are often found in this horizon. There are not many plant or animal remains but minerals are abundant in this layer.

The final horizon is **parent material** which could be bedrock or material deposited by a glacier, water, or wind. Parent material contains no organic material but does contain minerals. These minerals are found as sandstone, limestone, granite, or shale. Often, the parent material is a bedrock layer. This layer may be impermeable to water. Bedrock creates a place for groundwater to collect. This is called an aquifer. Wells can be drilled down to the aquifer and pump water up to our homes.

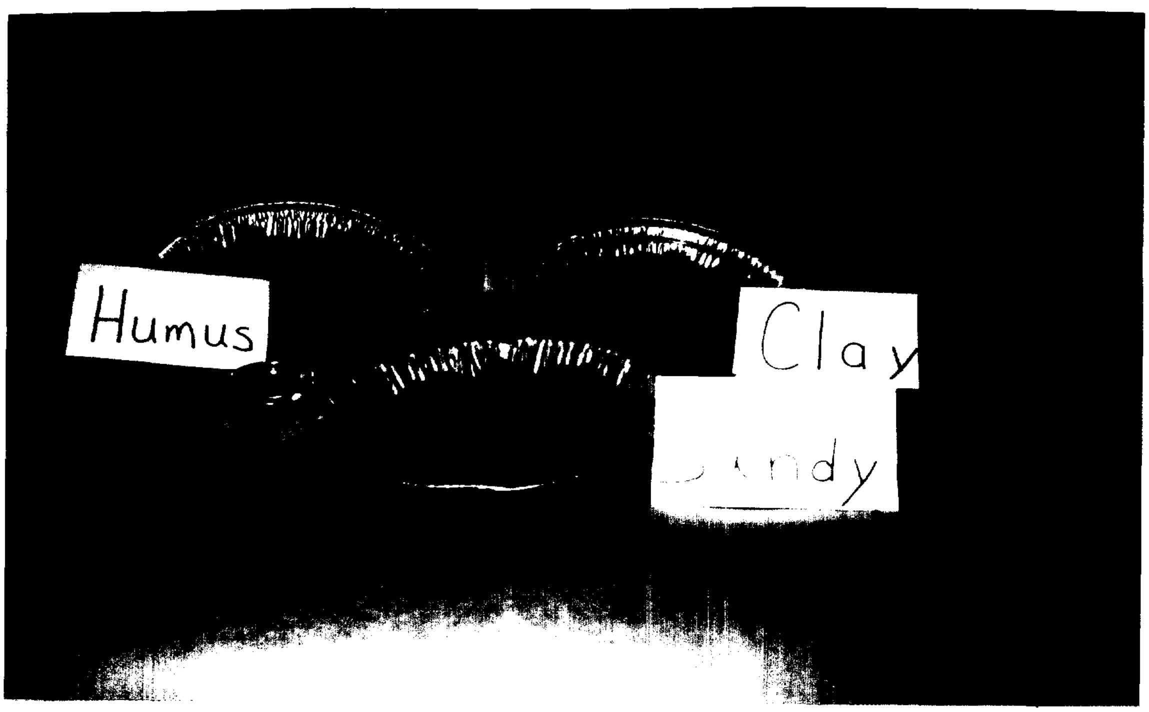
Topic: Soil: **Soil Observation Lab**

Objectives:
1. To observe and feel the different types of soil particles, how they are alike and how they are different.
2. To see what is in soil.

Materials: Samples of soil (preferably a sandy soil, clayey soil, silty soil, and humus) Sandy soils are often found near streams, clayey soils will by sticky and form balls, compost piles can contain humus.
Pie pans
Magnifying glasses
Sieves
Magnet

Background Information:
Many people think dirt is dirt. But, there are many different types of soil and each type has different uses. In order to recognize the differences in the types of soil, it is best to actually have different types in front of you to compare by color, particle size, smell, and touch.

Procedure:
1. Collect different types of soil samples. (It may also be interesting to have the children bring in samples from their yards.)



2. Place each sample in a pie pan. You may label each pan with the type of soil or allow the children to use investigative skills to discover which type of soils they think each pan contains.
3. Allow the children to examine the soil samples. This works best in small groups.
4. Tell the groups to look at color, particles size, smell, and particle shape. Also have them look for organic matter (twigs, grass, exoskeletons of bugs) and living creatures (worms, beetles, etc.).

Evaluation:

1. How does each soil feel compared to the others? (Clay is sticky and sticks together, silt is softer, sand is gritty and falls apart) Which is lumpiest? Which is driest? Dampest?
2. Which has the largest particles? Which has the smallest?
3. Which has the darkest color? Lightest?
4. What are the different shapes of particles? (This will be impossible to see without a microscope.)
5. Were any of the soils attracted to the magnet? (Some sands have magnetic properties.)
6. Did you find anything recognizable in the soil such as rocks, leaves, stems, nails, roots, seeds, etc.?
7. Which has the strongest smell? What does it remind you of?

Application: The properties that the children searched for are the same properties soil scientists use to identify soil types. They recognize the color and the feel of the soil and are able to determine its history. They are also able to recognize if something is wrong with the soil such as a smell of gasoline or pollutants added by humans to the soil. The dark color of soil indicates that organic matter is present. Organic matter is necessary to provide nutrients. Darker soils are richer in nutrients and often produce healthier plants and animals. Soil with organic matter or humus also contains moisture. To compare the moisture of the samples, place them in sealed plastic bags or jars with a piece of paper and compare the dampness of the paper.

Sources:

Jacobson, Willard J. and Abby B. Bergman. **Science Activities for Children**. Prentice Hall, Inc., New Jersey: 1983.

Westley, Joan. **Rocks, Sand, and Soil**. Creative Publications, California: 1988.

Topic: Soil: **Water and Air in Soil**

Objectives: 1. To observe that water and air are present in the spaces between soil particles.

Materials: 3 Mayonnaise jars with lids
Enough soil to fill the jars about ½ full

Background Information:

In order for plants and animals to survive, water and air must be present in the soil. Water and air are found in the tiny pores between the soil particles. These pores are so tiny that it may seem that there is not much water or air found there. Actually, the amount of fresh water found underground is more than there is aboveground! The tiny pore spaces add up! The following two experiments will help prove to the children that water and air are certainly present underground and their importance is essential for every living thing on Earth.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:

1. Fill two jars about ½ full of soil and weigh the jars.
2. Cover one jar and leave the other open.
3. Place the jars near a window where it is sunny.
4. Weigh the jars daily for a week and record the observations.

Evaluation:

1. What do you notice about the weight of the open jar compared to the closed jar as more and more time passes? (The open jar should weigh less because water has evaporated. The closed jar should weigh the same because water cannot escape.)
2. What might be causing the weight to go down? What is disappearing from the soil. (Water is evaporating.)

Application: You can apply this experiment by comparing different types of soils and soils at different depths. You will find that some soils contain more water than others. Soil found in deeper locations may also contain a different amount of water than soil found at the surface. Instead of letting the water evaporate into the air of the room, it might be helpful to put the lids on the jars and collect water on the sides of the jar. You can actually compare the amount of water in the soil this way. Which type of soils contain the most water?

Procedure:
1. Fill the jar about ½ full of soil and weigh the jar.
2. Slowly pour water to the top of the jar.
3. Notice what rises from the soil.

Evaluation:
1. Did you see tiny air bubbles rise from the soil?
2. What happened to the water level? (It should go down.) Why? (Water is being absorbed into the soil and pushing air out.)

Application: Try adding water to different types of soils to determine which soil contains the most air pores. You can compare the amounts of air present by putting the lids on the jars immediately after you have filled the jar with water. You should actually be able to measure with a ruler the air at the top of the jar, or the amount the water level dropped. Plastic wrap sealed by a rubberband around the top of the jar may allow for better viewing of the air bubble rather than a lid.

Sources: Simon, Seymour. **A Handful of Soil**. Hawthorn Books, Inc.: New York, 1970.

Topic: Soil: **Weathering**

Objectives:
1. To understand how weathering occurs.
2. To understand that water expands when it freezes

Materials:
1 Tin can
Water
Teaspoon
Freezer

Background Information:

Water has many unusual properties that make it unique and very useful in nature. One of these properties is that water takes up more room when it freezes and becomes ice. Water is the only substance found in nature that expands and gets lighter when it becomes a solid. Why is this important? Think of what happens in the winter when a lake freezes. Ice forms on the top of the lake, not the bottom. The ice floats because it is lighter than the water. This will protect the fish and plants. It also allows the sun to melt the ice. If ice sank to the bottom then the sun could not melt it and the fish would be forced to the surface of the lake. Water helps to break apart rocks because the water that seeps into a rock and freezes will expand and break the rock.

Weathering is very important for soil formation. There is a difference between weathering and erosion. Weathering is an extremely slow, almost unnoticeable process. Erosion occurs quickly and has negative impacts on the surrounding environments. This experiment will allow the class to see how weathering occurs and why it aids in creating more soil.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:
1. Fill a small empty tin can to the top with water. Use a teaspoon to add water until it can no longer be added.
2. Place the can in your freezer.
3. Remove the can the next day and notice what has happened.

Evaluation:
1. What do you notice about the ice in the can?
2. What happened to the amount of space the ice needed as compared to the water?
3. How can this be applied to how water and ice break a rock and form soil?

Application: Just because water expands when it freezes, does that make it heavier than water? Have the children think about this. The answer is no. A bucket of water is heavier than a bucket of ice. The reason is because water takes up less space than ice, more water molecules will be present in a bucket of water. If you were to compare the cans you used for the experiment, the frozen can would weigh the same as a can filled with water because you allowed the ice to come over the top of the can. If you had the same volume of ice and water, you must remove the ice that extends above the top of the can and then weigh it. Now the ice can would weigh less.

Try using a glass of water with ice cubes in it. Mark the level of the water and then allow the ice cubes to melt. The water level should go down.

If you want to prove that water is strong enough to break rocks, try filling a glass jar to the top with water and putting the lid on very tight. Place the jar in a paper bag and put it in a freezer. When you pull it out the next day, the jar should be broken.

Many people believe that global warming will cause the polar ice caps to melt and cause flooding. Based on this experiment, what would happen if the north and south poles melted. The water level should actually go down. This would be true but you also have to take into account all the ice that is on land that would melt and add more water to the oceans. This would raise the water level.

Sources: Berger, Melvin. **The New Water Book**. Thomas Y. Crowell Company: New York, 1973.

Topic: Soil: **Soil Settling**

Objectives: 1. To observe the different types of soil particles by color and weight.

Materials: 1 Jar with a lid
Enough soil to fill the jar about 1/4 full
Water

Background Information:

A soil sample may be made of many different types of soil textures: sand, clay, silt, rocks, humus. Each of these types of soil has particles with different sizes and weights. You can prove that a good soil is a mixture of all these different particles by separating them. Separtation is easy when you do it by weight. For this experiment, it may be fun for each child to bring in a jar and a soil sample from their own yard. This will allow the class to compare who has the most clay, sand, etc.

Hypothesis: Allow the children to use the information they have already to make an educated guess about what may happen in this experiment.

Procedure:

1. Fill the jar about 1/4 full of soil. Add small pebbles and remenants of leaves, sticks, and roots.
2. Fill the jar with water and close the lid tightly.
3. Shake the jar until all the soil is mixed up and is floating around.
4. Place the jar someplace it will not be disturbed and allow the soil to settle for about 5 minutes. Make observations.
5. Allow the soil to settle for 24 hours or until the water is clear.

Evaluation:

1. After 5 minutes of settling, what do you notice about the water?
2. What particles settled quickest? Why? Slowest? Why?
3. Notice the different colors of the layers. Does this help to figure out what type of soil may be in each layer?
4. What is floating on top? (Leaves, twigs-Organic Matter)
5. Try to label each layer. (The rocks settle first, then sand, silt, clay will settle after 24 hours, humus is floating on top)